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SCIENCE PRIMERS, *edited by*
Professors Huxley, Roscoe, *and*
Balfour Stewart.

IV.

PHYSICAL GEOGRAPHY.

Science Primers.

PHYSICAL GEOGRAPHY.

BY

ARCHIBALD GEIKIE, LL.D., F.R.S.,

Director of the Geological Survey of Scotland, and Murchison-Professor of Geology and Mineralogy in the University of Edinburgh.

WITH ILLUSTRATIONS.

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SCIENCE PRIMERS.

PHYSICAL GEOGRAPHY.

INTRODUCTION.

1. LET us suppose that it is summer-time, that you are in the country, and that you have fixed upon a certain day for a holiday ramble. Some of you are going to gather wildflowers, some to collect pebbles, and some without any very definite aim beyond the love of the holiday and of any sport or adventure which it may bring with it. Soon after sunrise on the eventful day you are awake, and great is your delight to find the sky clear and the sun shining warmly. It is arranged, however, that you do not start until after breakfast-time, and meanwhile you busy yourselves in getting ready all the baskets and sticks and other gear
f which you are to make use during the day. But the
rightness of the morning begins to get dimmed. The
w clouds which were to be seen at first have grown
ge, and seem evidently gathering together for a s
d sure enough, ere breakfast is well over, t
inous big drops are seen falling. You cling
e that it is only a shower which will soon b

and you go on with the preparations for the journey notwithstanding. But the rain shows no symptom of soon ceasing. The big drops come down thicker and faster; little pools of water begin to form in the hollows of the road, and the window-panes are now streaming with rain. With sad hearts you have to give up all hope of holding your excursion to-day.

2. It is no doubt very tantalizing to be disappointed in this way when the promised pleasure was on the very point of becoming yours. But let us see if we cannot derive some compensation even from the bad weather. Late in the afternoon the sky clears a little, and the rain ceases. You are glad to get outside again, and so we all sally forth for a walk. Streams of muddy water are still coursing along the sloping roadway. If you will let me be your guide, I would advise that we should take our walk by the neighbouring river. We wend our way by wet paths and green lanes, where every hedgerow is still dripping with moisture, until we gain the bridge, and see the river right beneath us. What a change this one day's heavy rain has made! Yesterday you could almost count the stones in the channel, so small and clear was the current. But look at it now! The water fills the channel from bank to bank, and rolls along swiftly. We can watch it for a little from the bridge. As it rushes past, innumerable leaves and twigs are seen floating on its surface. Now and then a larger branch, or even a whole tree-trunk, comes down, tossing and rolling about on the flood. Sheaves of straw or hay,
nks of wood, pieces of wooden fence, sometimes
r duck, unable to struggle against the current,
us and show how the river has risen above

its banks and done damage to the farms higher up its
course.

3. We linger for a while on the bridge, watching this
nceasing tumultuous rush of water and the constant
riety of objects which it carries down the channel.
u think it was perhaps almost worth while to lose
r holiday for the sake of seeing so grand a sight as
angry and swollen river, roaring and rushing with
ll burden of dark water. Now, while the scene
ll fresh before you, ask yourselves a few simple
ons about it, and you will find perhaps addi-
reasons for not regretting the failure of the
ed excursion.

the first place, where does all this added mass
in the river come from? You say it was the
brought it. Well, but how should it find its
this broad channel? Why does not the rain
e ground without making any river at all?
in the second place, where does the rain
? In the early morning the sky was bright,
appeared, and then came the rain, and you
it was the clouds which supplied the rain.
ls must have derived the water from some
w is it that clouds gather rain, and let it
the earth?
place, what is it which causes the river
lirection more than another? When
, and you could, perhaps, almost
nnel on the stones and gravel, the
it might be, was still quite
at the water was moving a
m the same quarter. And
lled with this rolling torre

dark water, you see that the direction of the current is still the same. Can you tell why this should be?

7. Again, yesterday the water was clear, to-day it is dark and discoloured. Take a little of this dirty-looking water home with you, and let it stand all night in a glass. To-morrow morning you will find that it is clear, and that a fine layer of mud has sunk to the bottom. It is mud, therefore, which discolours the swollen river. But where did this mud come from? Plainly, it must have something to do with the heavy rain and the flooded state of the stream.

8. Well, this river, whether in shallow or in flood, is always moving onward in one direction, and the mud which it bears along is carried towards the same point to which the river itself is hastening. While we sit on the bridge watching the foaming water as it eddies and whirls past us, the question comes home to us —what becomes of all this vast quantity of water and mud?

9. Remember, now, that our river is only one of many hundreds which flow across this country, and that there are thousands more in other countries where the same thing may be seen which we have been watching to-day. They are all flooded when heavy rains come; they all flow downwards; and all of them carry more or less mud along with them.

10. As we walk homewards again, it will be well to put together some of the chief features of this day's experience. We have seen that sometimes the sky is clear and blue, with the sun shining brightly and warmly in it; that sometimes clouds come across the sky, and that when they gather thickly rain is apt

We have seen that a river flows; that it is

wollen by heavy rain, and that when swollen it is apt
be muddy. In this way we have learnt that there
a close connection between the sky above us and
earth under our feet. In the morning, it seemed
a little thing that clouds should be seen gathering
rhead; and yet, ere evening fell, these clouds led
legrees to the flooding of the river, the sweeping
of trees, and fences, and farm produce; and it
even be to the destruction of bridges, the inun-
of fields and villages and towns, and a large
ction of human life and property.

But perhaps you live in a large town and have
ortunity of seeing such country sights as I have
scribing, and in that case you may naturally
imagine that these things cannot have much
or you. You may learn a great deal, how-
ut rain and streams even in the streets of a
tch a little of the rain in a plate, and you
to be so much clear water. But look at it
s along the gutters. You see how muddy
s swept away the loose dust worn by wheels
m the stones of the street, and carried it
ers. Each gutter thus becomes like the
r. You can watch, too, how chips of
bits of wood, and other loose objects
treet are borne away, very much as the
s are carried by the river. Even in a
, you can follow how changes in the sky
s on the earth.

hink for a little, you will recall r
ns of the way in which the co
ay life are connected together.
remember, you have been famili

such things as [illegible], clouds, wind, rain, rivers, frost, and snow, and they have grown so commonplace that you never think of [illegible] about them. You cannot imagine them, perhaps, as in any way different from what they are; they seem, indeed, so natural and so necessary that you may even be surprised when anyone asks you to give a reason for them. But if you had lived all your lives in a country where no rain ever falls, and if you were to be brought to such a country as this, and were to see such a storm of rain as you have been watching to-day, would it not be very strange to you, and would you not naturally enough begin to ask the meaning of it? Or suppose that a boy from some very warm part of the world were to visit this country in winter, and to see for the first time snow fall, and the rivers solidly frozen-over, would you be surprised if he showed great astonishment? If he asked you to tell him what snow is, and why the ground is so hard, and the air so cold, why the streams no longer flow, but have become crusted with ice—would you answer his questions?

13. And yet these questions relate to very common, everyday things. If you think about them, you will learn, perhaps, that the answers are not quite so *easily* found as you had imagined. Do not suppose that because a thing is common, it can have no interest *for* you. There is really nothing so common as not to deserve your [illegible]on, and which will not reward *you* for your pa[illegible]

14. In [illegible]g pages I propose to ask *you* to look with [illegible] of these common things. You must not [illegible]er, that it is my wish merely to set you c[illegible] which you have to learn, and

give you some rudiments of knowledge which you
ust commit to memory. I would fain have you not
o be content with what is said in this little book, or
n other books, whether small or great, but rather to
et into the habit of using your own eyes and seeing
r yourselves what takes place in this wonderful
rld of ours. All round you there is abundant
terial for this most delightful inquiry. No excur-
you ever made in pursuit of mere enjoyment and
nture by river, heath, or hill, could give you more
y pleasure than a ramble with eyes and ears alike
to note the lessons to be learnt from every day
om every landscape. Remember that besides
nted books which you use at home, or at school,
the great book of Nature, wherein each of us,
nd old, may read, and go on reading all through
out exhausting even a small part of what it
ach us.

is this great book—Air, Earth, and Sea—
ould have you look into. Do not be content
ly noticing that such and such events take
r instance, to return to our walk to the
er; do not let a fact such as a storm or
s without trying to find out something
et into the habit of asking Nature ques-
did in the course of our homeward walk.
ntil you get at the reasons for what you
on around you. In this way even the
ings will come to wear a new interest for
er you go there will be something f
something that will serve to in
which the landscape would oth
ill thus learn to use your eyes

and correctly; and this habit of observation will be of the utmost value to you, no matter what may be the path of life which lies before you.

16. In the following Lessons I wish to show you what sort of questions you may put about some of the chief parts of the book of Nature, and especially about two of these—the Air and the Earth. Each of us should know something about the air we breathe and the earth we live upon, and about the relations between them. Our walk showed us a little regarding these relations when it enabled us to connect the destruction of fences and farms with the formation of clouds in the sky. Many other relations remain for you to find out. In tracing these you are really busy with science, with that branch of science called Physical Geography, which seeks to describe this earth with all the movements which are going on upon its surface. And yet you are not engaged in anything very difficult or uninteresting. You are simply watching with attentive eyes the changes which are continually taking place around you, and seeking to find out the meaning of these changes, and how they stand related to each other.

THE SHAPE OF THE EARTH.

17. Before observing what takes place on the surface of the earth, it may be well if you form a clear notion about the shape of the whole earth as a mass, and if you fix in your minds some of the great leading features of the connection between the earth and the sun.

18. When you stand in the middle of a broad flat country, or look out upon the wide sea, it seems to

rou as if this world on which we live and move were great plain, to the edge of which you would come if ou went far enough onward. This is the first notion all have as children. It was also the firm belief mankind in early times. The sun and moon were n thought to rise and set only for the use of people e; and the sky, with all its stars, was looked upon great crystal dome covering and resting upon earth.

. But you can easily prove to yourselves that the s deceived about the flatness of the earth, and vhat seems quite level is in reality curved. In a evel country, such as many parts of the midland stern counties of England, you cannot see trees uses farther away than some four or five miles. If nb to the top of a church tower, you find many come into sight which you could not have m the ground. And if there should happen ange of hills in the neighbourhood, you would n their tops a still larger number of points fore were hidden. The higher you climb ground, therefore, the further you can see. ain: suppose you were at the bottom of a tall nd on looking out to sea were to note the listant ship. If you mounted to the top of ou might see not only the sails, but the el, and your eye would probably pick out further away, appearing as mere specks ine of meeting between sea and sky, and ould not see at all from the beach.

se further, that you were to sit down [illegible] cliff, and watch these vessels for [illegible] m, which at first were so far a[illegible] to you as they come and go, you observe **facts.** When you put the facts together, and reason out their connection and meaning, and find that they prove the roundness of the earth, you make an **induction** or inference from them. Now it is this union of observation and induction which makes **science.**

24. You may observe, then, and prove that the old and natural-enough notion about the flatness of the earth is quite untrue; and that, flat as the sea and land may appear, they are only parts of a great curve. If you were to set sail from England, and keep sailing on in the same general direction without turning back, you would in the end come to England again. You would sail round the world, and prove it to be actually a globe. Now, this has often been done. Many voyages have been made round the world, and, instead of coming to its edge, the voyagers, or "circumnavigators," as they are called, have always found the land and sea to wear the same curved surface which we can see for ourselves at home.

25. Though you may find it easy enough to believe that the surface of the earth is part of a curve when you look out upon the broad sea, yet when you see a landscape where the ground is very uneven, such, for example, as a region of high mountains and deep valleys, you may find perhaps some difficulty in understanding how it can possibly be that such an irregular surface can be spoken of as part of a curve. In reality, however, the earth is so big, that even the highest mountains are in comparison merely lik
s on the surface. It is only when the s
, as on a great plain or on the sea, that
judge by the eye as to the real forn

[illegible]

[illegible] measured [illegible] It's a mid- [illegible] at a [illegible] it would [illegible]

DAY AND NIGHT.

27. Day by day, as far back as you can remember, you have been accustomed to see the sun travel across the sky. Night after night, when the air has been free from cloud, you have seen the moon and stars sailing slowly overhead. You cannot be more confident of anything than you are that the sun will appear again to-morrow, and move on from year to year as it has done in the past. You have seen that a slow, regular, and unceasing motion seems to be going on all round the earth. Have you ever wondered what can be the cause of this motion?

28. When the sun shines it is warm, when clouds obscure the sky the air is more chilly, and at night, when the sun does not shine at all, we feel a sensation of cold. Again: by day the sky is filled with light, but when the sun sinks in the west darkness begins. You see from this that we depend upon the sun for light and heat. It is evident that we cannot properly understand what takes place upon the earth until we learn something about the relations of the earth to the sun.

29. Perhaps your first impression has been like that of mankind in general long ago. They believed the earth to remain as the fixed central point of the universe, round which sun, moon, and stars were ceaselessly revolving. To this day we speak of these heavenly bodies as **rising** and **setting**, as if we still regarded them as performing a journey round the earth.

30. But instead of being the centre of the arth is in reality only one of a number of

of the earth on its axis must bring alternate light and darkness to every country.

34. You must not suppose that there is any actual rod passing through the earth to form the axis round which it turns. The axis is only an imaginary line, and the two opposite points where it reaches the surface, and where the ends of the rod would come out were the axis an actual visible thing, are called the **North Pole** and the **South Pole.** They are represented by the two little points by which the school-globe is fixed in its place.

35. Round this axis the earth spins once in every twenty-four hours. All this time the sun is shining steadily and fixedly in the sky. But only those parts of the earth can catch his light which happen at any moment to be looking towards him. There must always be a bright side and a dark side, just as there was a bright side and a dark side when you placed the globe opposite to the candle. Now you can easily see that if there were no motion in the earth, half of its surface would never see the light at all, while the other half would never be in darkness. But since it rotates, every part is alternately illuminated and shaded. When we are catching the sun's light, we have **Day**; when we are on the dark side, we have **Night.**

36. The sun seems to move from east to west. The real movement of the earth is necessarily just the reverse of this, viz. from west to east. In the morning we are carried round into the sunlight, which appears in the east. Gradually the sun se climb the sky until we are brought directly to him at noon, and gradually he sinks again

ay from it, for it completely surrounds the earth. o this outer envelope of air, the name of Atmo- here is given.

41. From the experiments explained in the Chemis- y Primer (Art. 9) you learn that the air is not a simple bstance, but a mixture of two invisible gases, called trogen and oxygen. But besides these chief ingre- ents, it contains also small quantities of other sub- nces; some of which are visible, others invisible. If u close the shutters of a room, and let the sunlight eam through only one chink or hole into the room, u see some of the visible particles of the air. Hun- eds of little motes or specks of dust cross the beam light which makes them visible against the sur- nding darkness, though they disappear in full day- t. But it is the invisible parts of the air which of chief importance; and among them there are o which you must especially remember—the **vapour water** and **carbonic acid gas.** You will soon me to see why it is needful for you to distinguish ese.

42. Now what is this vapour of water? You will erstand its nature if you watch what takes place n a kettle boils. From the mouth of the spout a am of white cloud comes out into the air. It is in inual motion; its outer parts somehow or other ppear, but as fast as they do so they are supplied fresh materials from the kettle. The water in the e is all the while growing less, until at last, if you replenish it, the whole will be boiled away, and the kettle left quite dry. What has become the water? You have changed it into vapo not destroyed or lost in any way, it has on

from one state into another, from the liquid into the gaseous form, and is now dissolved in the air.

43. Now the air always contains more or less vapour of water, though you do not see it, so long as it remains in the state of vapour. It gives rise to clouds, mist, rain, and snow. If it were taken out of the air, everything would be dried up on the land, and life would be impossible. As you learn more and more of the changes which take place from day to day around you, you will come to see that this vapour of water plays a main part in them all.

44. Carbonic acid gas is also one of the invisible substances of the atmosphere, of which, though it forms no more than four parts in every ten thousand, yet it constitutes an important ingredient. You will understand how important it is when you are told that, from this carbonic acid in the air, all the plants which you see growing upon the land extract nearly the whol of their solid substance (see Chemistry Primer, Art 11). When a plant dies and decays, the carbonic aci is restored to the air again. On the other hand, plant are largely eaten by animals, and help to form th framework of their bodies. Animals in breathing give out carbonic acid gas ; and when they die, and their bodies decay, the same substance is again re stored to the atmosphere. Hence the carbonic ac of the air is used to build up the structure both plants and animals, and is given back again whe these living things cease to live. There is a continu coming and going of this material between the a and the animal and vegetable kingdoms (see Ch *mistry Primer,* Art. 13).

II. The Warming and Cooling of the Air.

45. You know that though you cannot see the air you can feel it when it moves. A light breeze, or a strong gale, can be just as little seen by the eye as still air; and yet we readily feel their motion. But even when the air is still it can make itself sensible in another way, viz. by its **temperature** (see Physics Primer, Art. 51). For air, like common visible things, can be warmed and cooled.

46. This warming and cooling of the air is well illustrated by what takes place in a dwelling-house. If you pass out of a warm room, on a winter's day, into the open air when there is no wind, you feel a sensation of cold. Whence does this sensation come? Not from anything you can see, for your feet, though resting on the frozen ground, are protected by leather, and do not yet feel the cold. It is the air which is cold, and which encircles you on all sides, and robs you of your heat; while at the same time you are giving off or **radiating** heat from your skin into the air (see Physics Primer, Art. 67). On the other hand, if, after standing a while in the chilly winter air you return into the room again, you feel a sensation of pleasant warmth. Here, again, the feeling does not come from any visible object, but from the invisible air which touches every part of your skin, and is thus robbed of its heat by you.

47. Air, then, may sometimes be warm and sometimes cold, and yet still remain quite invisible. By means of the thermometer (which is explained in the P[illegible]ics Primer, Art. 51), we can measure [illegible] c[illegible]s of heat and cold, which even the s[illegible]e skin would fail to detect.

You must often have noticed the change of temperature, when, after the sun has been shining for a time, a cloud comes between it and the earth. Immediately a feeling of chilliness is experienced, which passes off as soon as the cloud has sailed on, and allowed the sun once more to come out.

53. The air itself absorbs some of the sun's heat, and the greater the thickness of air through which that heat has to make its way, the more heat will be absorbed. Besides this, the more the rays of heat are slanted the weaker do they become. At noon, for example, the sun stands high in the sky. Its rays (as at B in Fig. 3) are then nearest to the vertical, and have also the least thickness of air to pass through before they reach us. As it descends in the afternoon, its rays get more and more slanted, and must also make their way through a constantly increa
ss of air (as at C in the diagram). Her
of the day is much warmer than mor

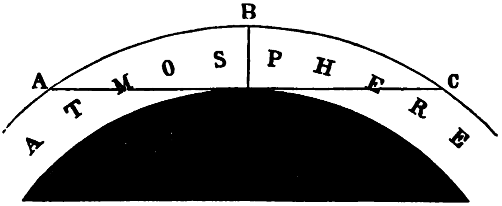


FIG. 3.—Diagram showing the influence of the varying thickness of the atmosphere in retarding the Sun's heat. A. Line of Sun's rays in the morning. B. Line of the rays at noon. C. Line of the rays at sunset.

54. At night, when the sun no longer shines, its heat does not directly warm the part of the earth in shadow. That part has [illegible] [illegible] no heat from it, but even radiates [illegible] its heat into the cold sky (see Art. 58). Hence night is much cooler than day.

55. Then, again, in summer the sun at noon shines much higher in the sky and is more directly overhead, than in winter. Its heat comes down less obliquely and has less depth of air to pass through, and hence is much more felt than in winter, when, as you know, the sun in our part of the world never rises high even at midday.

56. From all this it is evident that we get our supplies of heat from the sun, and that anything coming between us and the sun serves to interrupt this heat and give us the sensation of cold.

57. Still, if we were dependent for our warmth upon the direct heat of the sun alone, we should be warm only when the sun shines. A cloudy day would be [illegible] intensely cold one, and every night as intensely [illegible] as it ever is in winter. Yet such is not the [illegible] Cloudy days are often quite warm; while we are aware that the nights are by no means always very [illegible] There must be some way in which the sun's [illegible] stored up, so that it can be felt even when he [illegible] shining.

58. Let [illegible] have recourse to our first illustration. [illegible] the back of a chair opposite to [illegible] it gets so hot that you can [illegible] the chair to a distant part [illegible] cools. Hence a part of [illegible] been absorbed by the

59. In like manner in summer the ground gets warmed; in some parts, indeed, becoming even so hot at times that we can hardly keep the hand upon it. In hot countries this is felt much more than in Britain. Soil and stones absorb heat readily, that is to say, soon get heated, and they soon cool again. When they have been warmed by the sun, the air gets warmed by contact with them, and keeps its heat longer than they do; so that even when at night the soil and stones have become ice-cold, the air a little above is not so chilly. On the other hand, when the surface of the ground is cold, it cools the air next it. The ground parts easily with its heat, and a vast amount of heat is in this way radiated at night from the earth outward into the cold starry space. Much more heat, however, would be lost from this cause did not the abundant aqueous vapour of the atmosphere (Art. 43) absorb part of it, and act as a kind of screen to retard the radiation. This is the reason why in hot climates, where the air is very dry—that is, contains a small proportion of the vapour of water—the nights are relatively colder than they are in other countries where the air is moister. In like manner, clouds serve to keep heat from escaping; and hence it is that cloudy nights are not so cold as those which are clear and starry.

60. The atmosphere, then, is heated or cooled according as it lies upon a warm or cold part of the earth's surface; and, by means of its aqueous vapour, it serves to store up and distribute this heat, keeping the earth from such extremes of climate as would otherwise prevail.

place of that which rises. All the air which lies abo the burning coal gets warmer and lighter; it therefo flows up the chimney, carrying with it the smoke ar gases. You will understand that though a brig blazing fire is a pleasant sight in winter, we do n get all the heat which it gives out. On the contrar a great deal of the heat goes up the chimney; an except in so far as it warms the walls, passes away an warms the outer air.

64. What happens in a small way in our houses tak place on a far grander scale in nature. As alread pointed out (Art. 50), the sun is the great source heat which warms and lightens our globe. While th heat of the sun is passing through the air, it does ver little in the way of warming it. The heat goes throug the air, and warms the surface of the earth. You kno that in summer the direct rays of the sun are ho enough to burn your face, and yet, if you put even thin sheet of paper over your head, enough to cut o these rays, the sensation of burning heat at once goe off, although the same air is playing about you all th time.

65. Both land and water are heated by the sun' rays, and the same change in the air then takes plac which we find also at our firesides. The layer of ai next the warmed earth becomes itself warmed. As i thereby grows lighter it ascends, and its place is taken by colder air, which flows in from the neighbourhood its place. This flowing in of air is **Wind.**

is asy for you now and then to watch how

Suppose, for instance, that d pend some time at the sea-coa early part of the day a gentl

round. The air is constantly heated to a hi
ee, and streams upwards in ascending curren
just as the hot air along this central belt mour
into the higher regions of the atmosphere, t
ler air from north and south flows in along t
ace to supply its place. This constant streami
air into the equatorial regions forms what are knov
the Trade Winds. The steadiness of these winc
d the way in which they may be counted upon
vigation, led long ago to their being called by the
esent name.

69. In our country the winds are by no means
gular and constant. If you look at the map, ar
ark the position of Britain upon the surface of t
arth, you will readily notice some obvious reaso
hy our winds should be variable. To the west li
wide Atlantic Ocean; to the east, beyond t
ow and shallow North Sea, stretches the vast co
ntal mass of Europe and Asia. Seas and lan
ch colder than ours lie to the north; others muc
mer than ours spread to the south. So that, wit
variable a surface receiving the sun's heat, we ma
quite prepared to find that sometimes a warm win
ws from one quarter, and sometimes a cold win
om another.

IV. The Vapour in the Air. Evaporatio
nd Condensation.

One of the most important ingredients in th
the Art. 41, to be the vapour of water
first of all, how it gets int
see, in this case, as before, yo
nd in science often adm
stions

a simple wa
a quantity
this invisibl
nixes with
But if yo
the vapou
ure. Take
urface, and
at once sho
because the
lled and ca
is condens
rror to make
old air aroun
comes from
mist which a
ble.

76. As the
pour diminishe
perature at w
pour dissolved,
nd becomes visi
kes place is th
see Art. 85).

77. Perhaps y
so universally
and where it co
into a plate, an
will note, in the
has se n
of i

[illegible] the earth, from every [illegible] and from the great sea [illegible] passing off into vapour [illegible] by the air. This pro- [illegible] and the water which [illegible] evaporate.

[illegible] more vapour than cold [illegible] vigorous in sunshine [illegible] than during winter. [illegible] difference in the rate [illegible] When the sun shines [illegible] may be enough to [illegible] and make them [illegible] weather is cold and [illegible] for days together. [illegible] greedily absorbs the [illegible] in the other, the [illegible] small quantities. [illegible] evaporation goes [illegible] got all the [illegible] in solution. On a [illegible] however, when the air contains about as [illegible] vapour as it can hold at that particular tempera- [illegible] evaporation is quite feeble, or ceases altogether. [illegible] capacity of the air for vapour is the [illegible] laundresses find so much difference be- [illegible] in the ease with which they can have [illegible] dried. On some days the air is busy [illegible] vapour everywhere, and then the clothes [illegible] Such is especially the case when the [illegible] the wind [illegible], because every moment [illegible] of air [illegible] in contact with the [illegible] off some [illegible] vapour, and passes on make way for fresh supplies of thirsty air. Oı er days, the air can hardly hold any more vapour l the clothes are found at the end of the day tc almost as wet as when they were hung out in the ming.

o. When water evaporates, the vapour carries away ıe of the heat of the water with it. Put a drop of er on the back of your hand, and let it evaporate; notice a sensation of cold, because in evaporating vapour has robbed your skin of some of its heat. ; abstracted heat is given out again into the air, n the vapour is condensed.

ι. You see, then, that the air contains invisible ous vapour, which though very small in quantity, ı compared with the amount of nitrogen and en, is yet enormous when the whole mass of the sphere is considered; that this vapour rises from r water-surface over the whole earth by the pro- of evaporation, and that it is brought back again the liquid form by the process of condensation.

Dew, Mist, Clouds.

After sunset, when the sky is clear, you know he grass gets wet with dew. In the morning you see mists hanging over woods, and streams, and nd gradually melting away as the sun mounts ky. At all times of the year you may watch uds form and dissolve, and form again, ever their size and shape as they move through Now these are all examples of the co our. Let us see how the proces

sation, as we have seen (Art. 76)

4

[illegible] combined [illegible] running water [illegible]

[illegible] ground is

chilled below its point of condensation, and the excess of vapour is deposited as dew upon the grass, twigs, stones, and other objects. Hence it is that the emperature at which this condensation begins to ake place is called the **Dew-point** (Art. 76).

86. **Mist and Fog.**—Another way in which a cold urface of the earth may produce condensation is hown by what takes place among mountains. When warm moist wind blows upon a chill mountain top, e air is cooled, and its vapour becomes visible the form of a mist or cloud. You can often see at the cloud is quite solitary, and even shapes itself the form of the ground, as if it were a sort of ecy cap drawn down over the mountain's head. his is often well marked in the morning. As day vances, the ground, warmed by the sun, no longer ols the air, and hence the mist is gradually re- sorbed into the atmosphere. But by and by, at the ming on of night, when the ground is once more oled by radiation, if there should be vapour enough the air, the mist will re-form, and the mountain t on his cap again.

7. Cold air, as well as cold ground, condenses the our of warmer air. If you watch what goes on ng the course of a river, you will often see exam- of this kind of condensation. The ground on er side of the river parts with its heat after down sooner than the river itself does, and con- ently cools the air above it more than the air e the river is cooled. So when this colder air either side moves over to take the place o er damp air lying on and rising from th ensation ensues in the form of the mist or

[illegible] cloud.

[illegible] On a summer morning the sky is often free from cloud. As the day advances and the earth gets warmed, misty vapour is formed, and is then carried upward by the ascending air-currents into the higher and colder parts of the atmosphere. It is chilled into the white fleecy clouds which are seen forming about midday and in the afternoon. Towards evening, when less evaporation takes place the clouds cease to grow, and gradually lessen in size until at night the sky is quite [illegible]. They have been dis-

ved again by descending and coming in con
th the warm air nearest to the earth. Again,
ve often noticed that clouds move across the
ey are driven along by upper currents of air,
course the stronger these currents are the faste
clouds travel. In this way the sky is someti
mpletely overcast with clouds which have co
om a distance. By watching these comings
ings of the clouds, you see how the state of
pour in the atmosphere continually changes.
ne time it is condensed into clouds, at anot
me evaporated and made invisible by the vary
rents of the air.

I. Where Rain and Snow come fro

You have now traced the vapour which
heat raises from the rivers, lakes, and s
e earth, and you have found it to be conden
into visible form in the clouds. But the clo
t remain always suspended in the sky. So
they melt away again, and are dissolved i
ble vapour. But they often disappear in anot
They let their moisture fall through the ai
arth, and thus give rise to rain and snow.

Rain.—You are well aware that rain alw
from clouds in the sky. When the sky is cl
ead, no rain falls. Only when it gets overc
the rain come. You can watch a dark r
gather itself together and discharge a he
upon the earth. In the illustration of
lass brought into the warm room
ber that the film of mist forme
ound by degrees to gather

[illegible] solid surface. [illegible]
[illegible] in the sky are [illegible]
[illegible] separated by [illegible]
[illegible] particles wh[illegible]
[illegible] case, the drop[illegible]
[illegible] other case, they [illegible]
[illegible] therefore [illegible]
[illegible] The minute [illegible]
[illegible] particles. [illegible]
[illegible]

warm room it soon melts into water, and you may ive off the water as before into vapour. Ice is the neral name given to water when it is in the solid te, such forms as snow and hail being only different pearances which ice puts on. Whenever water be-omes colder than a certain temperature it passes into e, or **freezes**, and this temperature is consequently own as the **freezing-point** (Physics Primer, t. 51).

95. You might suppose that ice is but a shapeless ing. But gather a few snowflakes, and, that they may t melt, examine them out of doors. When they lie

FIG. 4.—Forms of Snowflakes.

ether in a mass they have a pure opaque whiteness, t in reality they are as transparent as water; and it only from the way in which they scatter the light m their many glistening points, that they appear ite. To assure yourselves of this fact, carefully parate one or two of the flakes upon some dark face (the sleeve of a coat will do well), and you ll find that each flake is a more or less perfect sta h six rays, formed of little needles or crystals e transparent ice. The flakes are so delicate th ng through the air they are apt to be damage ing against each other. Some of the wn in Fig. 4.

The upper layers of the atmosphe

colder than the freezing-point of water. In the condensation which takes place there, the clouds do not resolve themselves into rain. The vapour of the upstreaming currents of warm air from the earth's surface is condensed and frozen in these high regions, and passes into little crystals, which unite into flakes of snow. Even in summer the fine white cloudlets which you see floating at great heights are probably formed of snow. But in those countries, such as ours, where in winter the air even at the surface is sometimes very cold, the snow falls to the ground, and lies there as a white covering, until returning warmth melts it away.

97. Besides rain and snow, the moisture of the air takes sometimes the form of **Hail**, which consists of little lumps of ice like frozen rain; and of **Sleet**, which is partially melted snow. But rain and snow are the most important, and it is these two forms which we must follow a little further.

98. **Summary.**—Before doing so, let us gather together the sum of what has been said about the aqueous vapour of the air. We have learnt that, as every sheet of water on the face of the globe evaporates, the air is full of vapour; that this vapour is condensed into visible form, and appears as dew, mist, and cloud. We have learnt further, that the vapour of which clouds are formed is resolved into rain and snow, and, in one or other of these forms, descends to the earth again. There is thus a circulation of water between the solid earth beneath and the air above. This circulation is as essential to the earth in making a fit habitation for living things, as the circulation of ood is in keeping our bodies alive. It mixes and

away impurities, such as those
mneys of a town. It moistens
which it renders capable of sup-
t supplies springs, brooks, and
s the very mainspring of all the
important a part of the machinery
our careful consideration. Let
fore, to what becomes of the rain
they have been discharged from
face of the earth.

ATION OF WATER ON THE LAND.

omes of the Rain.

ir is continually evaporating water
of the earth, and continually restoring
densation, yet, on the whole and in
years, there seems to be no sensible
of water in our seas, lakes, and rivers;
wo processes of evaporation and con-
balance each other.

is evident, however, that the moisture pre-
at any moment from the air is not at once
ted again. When a shower of rain falls, the
are not dry the moment the shower is over.
when heavy rain continues for hours togethe
whole country round may be flooded, and wil
rhaps, re ain so for days after the rain has cease
disap rance of the water is due in part t
t only in part. A great dea
ther ways.

n which falls upon the

the ground dry now? No; because some of the r has soaked into the earth. And if you could dig de enough, or if you were to notice what goes on wh workmen are making a deep excavation, you wou find that the ground underneath is not merely dam but that it contains plenty of water, and that you cou collect this water, and bring it up to the surfa Clearly, then, a good deal of the rain which fa upon the land must sink underground and gather the You may think that surely the water which disappea in that way must be finally withdrawn from the gener circulation which we have been tracing. When sinks below the surface, how can it ever get up to t surface again?

104. Yet, if you consider for a little, you will b convinced that whatever becomes of it underneath cannot be lost. If all the rain which sinks into th ground were for ever removed from the surface ci ulation, you will at once see that the quantity of wate upon the earth's surface must be constantly and visibl diminishing. The seas must be getting narrower an hallower; the rivers and lakes must be drying u ut no such changes, so far as can be seen, are reall aking place. The sea rolls as broadly and deeply a has done for many generations past, and the lake nd rivers remain very much the same. So that i of the water which sinks into the earth is neve ored to the surface again, it must be so small a par make no sensible difference on the amount which tored. In spite of the rain which disappe d, the circulation of water between and the sea continues without p n.

105. You are driven to conclude, therefore, that there must be some means whereby the water underground is brought back to the surface. This is done, as you will learn in the next section, by **Springs**, which gush out of the earth, and bring up water to feed the **Brooks** and **Rivers**, whereby it is borne into the sea.

106. You can now answer the question, *What becomes of the Rain?* Most of it sinks into the earth, and afterwards comes out again in *springs*; *part of* it is collected into brooks and rivers; and this part, in so far as not evaporated, works its *way over the* land and falls at last into the sea.

107. Here, then, are two distinct courses *which the* rainfall takes—one below ground, and one above. It will be most convenient to follow the *underground* portion first.

II. How Springs are formed.

108. In this Lesson we are to follow the course of the part of the rain which sinks below ground. A [illegible] attention to the soils and rocks which form the [illegible] of a country is enough to show *that they* differ [illegible]ly from each other in hardness, and in texture or [illegible]. Some are quite loose and porous, *others* are [illegible] and [illegible]grained. They consequently differ [illegible] in [illegible]ntity of water they allow *to pass* [illegible] bed of sand, for example, is per[illegible]ill let water sink through it *freely*, [illegible]rains [illegible]d lie loosely together, [illegible] onl[illegible] points, so as to *leave* [illegible]ween, [illegible]er *readily* finds its [illegible] In fact, the sand-

bed may become a kind of sponge, quite saturated with the water which has filtered down from the surface. A bed of clay, on the other hand, is **impervious**; it is made up of very small particles fitting closely to each other, and therefore offering resistance to the passage of water. Wherever such a bed occurs, it hinders the free passage of the water, which, unable to sink through it from above on the way down, or from below on the way up to the surface again, is kept in by the clay, and forced to find another line of escape.

109. Sandy soils are dry because the rain at once inks through them; clay soils are wet because they etain the water, and prevent it from freely descending nto the earth.

110. When water from rain or melted snow sinks elow the surface into the soil, or into rock, it does ot remain at rest there. If you were to dig a deep ole in the ground, you would soon find that the water hich lies between the particles would begin to trickle ut of the sides of your excavation, and gather into pool in the bottom. If you baled the water out, it ould still keep oozing from the sides, and the pool ould ere long be filled again. This would show you at the underground water will readily flow into any nnel which it can reach.

v the rocks beneath us, besides being in porous in their texture, such as sandstone, or less traversed with cracks—sometimes ike those of a cracked window-pane, but ide and open clefts and tunnels. The hannels serve as passages for the Hence, although a rock ma [illegible] soak [illegible] supplied [illegible] quantity of [illegible] is a [illegible] water can [illegible] cracks or [illegible] are often [illegible] great deal of [illegible]

[illegible] of the [illegible] you [illegible] wet, even [illegible] The soil every- [illegible] land by [illegible] in spite of [illegible] Plainly [illegible] the rest [illegible] They get it [illegible] coming out [illegible] of [illegible] the ground wet and [illegible] In other places you will observe that the [illegible] the ground. If [illegible] up to its source, you [illegible] out of the ground as [illegible]

[illegible] the natural outlets for the under- [illegible] you ask, why should this water [illegible] what makes it rise to the [illegible]

[illegible] 5) represents the [illegible] ard to each other, and in which you would meet with them if you wer cut a long deep trench or section beneath the surfa They are arranged, as you see, in flat layers or be Let us suppose that *a* is a flat layer of some imp vious rock, like clay, and *b* another layer of a por material, like sand. The rain which falls on the s face of the ground, and sinks through the upper b will be arrested by the lower one, and made either gather there, or find its escape along the surface of t

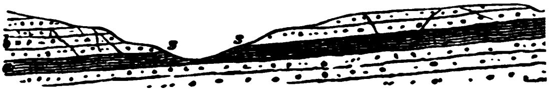


FIG. 5.—Origin of Surface Springs.

lower bed. If a hollow or valley should have its bott below the level of the line along which the water flo springs will gush out along the sides of the valley, shown at *s s* in the woodcut. The line of escape m be either, as in this case, the junction between t different kinds of rock, or some of the numero joints already referred to. Whatever it be, the wat annot help flowing onward and downward, as long ere is any passage by which it can find its way; an e rocks underneath are so full of cracks, that it h no diffic ng so.

It happen that a great deal of th
und escends far below the level of th
val elow the level of the sea. An
pe ld descend for several miles,
surface again. To reali
let us follow a particul
when it sinks into th

rain, to the time when, after a long journeying up and down in the bowels of the earth, it once more reaches the surface. It soaks through the soil together with other drops, and joins some feeble trickle or some more ample flow of water, which works its way through crevices and tunnels of the rocks. It sinks in this way to perhaps a depth of several thousand feet

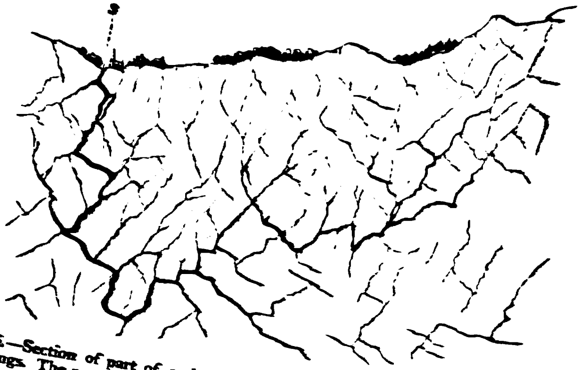


Fig. 6.—Section of part of a district to show the origin of deep-seated Springs. The numerous joints in the rocks lead the water down into a main channel, by which it re-ascends to the surface as a spring at s.

until it reaches some rock through which it cannot
readi ke further way. All this while it has been fol-
low er drops, coursing after it through its wind-
ir down to the same barrier at the bottom.
all these drops forms an accumulation
h is conti pressed by what is de-
the surfa able to work its way
pent-up st try to find escape
r directio ressure from abov

it is driven through other cracks and passages, win up and down until at last it comes to the surface ag It breaks out there as a gushing spring (see Phy Primer, Art. 23).

116. Thus each of the numerous springs wh issue out of the ground is a proof that there is a culation of water underneath, as well as upon surface of the land. But besides these nat outlets, other proofs are afforded by the artif openings made in the earth. Holes, called **We** are actually dug to catch this water. Mines, quarries, and deep excavations of any kind, usually troubled with it, and need to be kept by having it pumped out.

III. The work of Water underground.

117. No form of water seems purer than the c crystal spring as it comes bubbling out of the ea Water, perfectly pure in a chemical sense, should c sist only of the two elements Oxygen and Hydrog But in the water of every spring, no matter how cl and sparkling it may be, there is something else. you take a quantity of perfectly pure water and boi down, you may drive the whole of it off in steam, a not a vestige of anything is left behind. Rain tal up a little impurity from the air, yet may be regard very nearly pure water. But if you boil down ntity of spring water, you find a residue of so er. Sparkling transparency is thus no guide chemical purity of the water (see Chemis rts. 20, 21).

now rain is water nearly in a stat
r journeying up and down und

[illegible] from [illegible] When [illegible] and [illegible]

[illegible] and [illegible]

[illegible] As [illegible]

[illegible] field [illegible]

roots in it. It contains always more or less organic matter, and therefore (Art. 44) carbonic and some other acids. If you put some of the soil on a piece of iron and thrust it into the fire, you will burn off the organic matter, remove the carbonic acid, and change the colour of the soil.

122. Armed with the carbonic acid which it gets from the air, and with the larger quantity which it abstracts from the soil, rain-water is prepared to attack rocks, and to eat into them in a way which pure water could not do (see Chemistry Primer, Experiment 28).

123. Water containing carbonic acid has a remarkable effect on many rocks, even on some of the very hardest. It dissolves more or less of their substance, and removes it. When it falls for instance on chalk or limestone, it almost entirely dissolves and carries away the rock in solution, though still remaining clear and limpid. In countries where chalk or limestone is an abundant rock, this action of water is sometimes singularly shown in the way in which the surface of the ground is worn into hollows. In such districts, too, the springs are always **hard**; that is, they contain much mineral matter in solution, whereas rain-water and springs which contain little impurity are termed **soft** (Chemistry Primer, Art. 26).

124. Many of the substances abstracted from below by the water of springs are useful in the life of plants and of animals. Lime, salt, and iron, for example, are all brought up in spring-water, and are all of great value. Lime furnishes material for the bones of animals, and iron supplies the colouring matter of their blood. We obtain, indeed, most of what we need of these materials from our solid food; yet sprin

tunnels for the water underground, for the water is always eating away a little of the surface over which it flows, thereby widening the cracks and crevices, and converting them by degrees into wider passages. In this way large caverns many feet high and many miles long have been formed underneath the surface in different parts of the world.

IV. How the surface of the Earth crumbles away.

126. When a stone building has stood for a few hundred years, the smoothly dressed face which its walls received from the mason is usually gone. The stones are worn into holes and furrows, the carvings over window and doorway are so wasted that perhaps you cannot make out what they were meant to represent. This time-eaten character of old masonry is so familiar that one always looks for it in an old building, and when it is absent he at once doubts whether the building can really be old.

127. Again, in the burying-ground surrounding a venerable church you see the tombstones more and more mouldered the older they are. Sometimes, especially in towns, the inscriptions dating from more than a few generations back are so greatly wasted that you cannot now tell whose names and virtues they were set up to commemorate.

128. This crumbling away of hard stone with the lapse of time is a common familiar fact to you. But ha you ever wondered why it should be so? What ma s the stone decay, and what purpose is ser e ocess?

1 . In the case of buildings and other

ch portions of the rocks as it can remove. In the
se of some rocks, such as limestone, the whole, or
most the whole, of the substance of the rock is
rried away in solution. In other kinds, the portion
ssolved is the cementing material whereby the mass
the rock was bound together; so that when it is
ken away, the rock crumbles into mere earth or
nd, which is readily washed away by the rain.
ence one of the causes of the mouldering of stone
the action of the carbonic acid taken up by rain.

133. In the second place, the **oxygen** of the por-
n of air contained in rain-water helps to decompose
cks. When a piece of iron has been exposed for a
ne to the weather, in such a damp climate as that of
itain, it rusts. You know how, in the course of years,
n railings get quite eaten through, and how you can
rape the dirty yellow crust or powder from the cor-
ded surfaces. This rust is a compound substance,
rmed by the union of oxygen with iron. It con-
nues to be formed as long as any of the unrusted
on remains, since as each crust of rust is washed oft
new layer of iron is laid open to the attacks of the
ygen. What happens to an iron railing or a steel
nife, happens also, though not so quickly nor so
rongly, to many rocks. They, too, rust by absorbing oxygen. A crust of corroded rock forms on their surface, and, when it is knocked off by the rain, a fresh layer of rock is reached by the ever-present and active oxygen.

134. In the third place, the surface of many parts of the world is made to crumble down by means of **frost.** You are, no doubt, acquainted with s
the effects of frost. You have, probably, noti

ing up the soil, and opening it out for the roots an bres of plants. When a surface of rock has bee ell soaked with rain, and is then exposed to frost e grains of the rock undergo the same kind of pres re from the freezing of the water in the pore tween them. They are not so loose and open, how- er, as those of the soil are, and they withstand the tion of the frost much better. Of course, the most rous rocks, or those which hold most water, are st liable to the effects of this action. Porous cks, such as sandstone, are often liable to rapid cay from frost. The stone has crust after crust eled off from it, or its grains are loosened from h other and washed away by rain.

137. Again, water freezes not only between the com- ent grains, but in the numerous crevices or joints, they are called, by which rocks are traversed. You e, perhaps, noticed that on the face of a cliff, or in uarry, the rock is cut through by lines running e or less in an upright direction, and that by ns of these lines the rock is split up by nature, can be divided by the quarryman into large four- d blocks or pillars. These lines, or joints, have n already (Art. 111) referred to as passages for er in descending from the surface. You can under- d that only a very little water may be admitted time into a joint. But by degrees the joint widens tle, and allows more water to enter. Every time water freezes it tries hard to push asunder the two of the joint. After many winters, it is at last parate them a little; then more water force is exerted in freezing, until at ck traversed by the joint is complet

fallen to the ground. In countries exposed to severe winters, the waste caused by frosts along lines of steep cliff is often enormous.

139. In addition to carbonic acid, oxygen, and frost, there are still other influences at work by which the surface of the earth is made to crumble. For example, when, during the day, rocks are highly heated by strong sunshine, and then during night are rapidly cooled by radiation, the alternate expansion and contraction caused by the extremes of temperature loosen the particles of the stone, causing them to crumble away, or even making successive crusts of the stone fall off.

140. Again; rocks which are at one time well soaked with rain, and at another time are liable to be dried by the sun's rays and by wind, are apt to crumble away.

141. And thus you see that from a variety of causes the solid rocks of the earth are liable to continual decay
and removal. [illegible] hardest stone, as well as the softest,
must yield [illegible] d, and moulder down. They do
not all [illegible] at the [illegible] ate. If you look
more [illegible] wall [illegible] ent building, you
will [illegible] degree of decay.
[illegible] at all, while others
[illegible] kes place in a build-
[illegible] place also in nature,
[illegible] kind of stone
[illegible] d will do so
[illegible]

[illegible] a general
[illegible] the [illegible] you
[illegible] ould [illegible] orld

so fair and beautiful, that you cannot perhaps realize to yourselves, that there should be so much decay on its surface. You may be even inclined at first to consider the decay as a misfortune hardly to be explained. But instead of being a misfortune, the mouldering of the surface is in reality necessary to make the earth fit to be the dwelling-place of plants and animals. To it we owe the scooping out of valleys, and ravines, and the picturesque outlines of crags and hills. Out of the crumbled stones all soil is made, and on the formation and renewal of the soil we depend for our daily food. How this is brought about will be told in the next Lesson.

V. What becomes of the crumbled parts of Rocks. How Soil is made.

143. Take up a handful of soil from any field or garden, and look at it attentively. What is it made of? You see little pieces of crumbling stone, particles of sand and clay, perhaps a few vegetable fibres; and the whole soil has a dark colour from the decayed remains of plants and animals diffused through it. Now let us in the present Lesson try to learn how these different materials have been brought together.

144. We return again to the general mouldering of the surface of the land. The words "decay," "waste," and others of similar meaning, are applied to this process. But in reality, although the rocks may crumble away, and thereby grow less in size year by year, there is no actual loss of material to the surface of the earth. *The substance* of the rock may decay, *but it is not destroyed.* It only changes its condition and its form

What, then, becomes of all this material which is cor tinually being worn from the rocks around us?

145. Every drop of rain which falls upon the lan helps to alter the surface. You have followed th **chemical** action of rain when it dissolves parts c rocks. It is by the constant repetition of the process drop after drop, and shower after shower, for year together, that the rocks become so wasted and worr But the rain has also a **mechanical** action.

146. Watch what happens when the first patterin drops of a shower begin to fall upon a smooth surfac of sand, such as that of a beach. Each drop make a little dint or impression. It thus forces aside th grains of sand. On sloping ground, where the drop can run together and flow downward, they are abl to push or carry the particles of sand or clay along This is called a mechanical action; while the actua solution of the particles, as you would dissolve suga lt, is a chemical action. Each drop of rain may either or both of these ways.

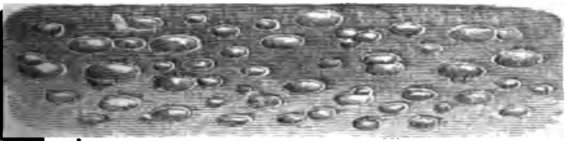


FIG. 9.—Prints impressed on Clay or Sand by Drops of Rain.

Now you will readily see how it is that rain muc in the destruction of rocks. It not only some parts of them, and leaves a crum n the surface, but it washes ereby exposes a fresh surface

down and making new earth. And thus, day by da
the soil is slowly renewed.

151. Plants, also, help to form and renew the so
They send their roots among the grains and joints
the stones, and loosen them. Their decaying fibr
supply most of the carbonic acid by which these ston
are attacked, and furnish also most of the orgar
matter in the soil. Even the common worms, whi
you see when you dig up a spadeful of earth, are
great service in mixing the soil and bringing what li
underneath up to the surface.

152. When we think about this decay and renew
of soil, we see that in reality the whole surface of tl
land may be looked upon as travelling downward
seaward. The particles worn from the sides an
crests of the high mountains may take hundreds
thousands of years on the journey; they may lie fo
a long time on the slopes; they may then be swep
down and form part of the soil of the valleys; thenc
they may be in after years borne away and laid dow
on the bed or bank of a river; and thus, after man
halts by the way, they at last reach the sea.

153. In order to form some idea of the extent t
which the surface of the land is cleared of its loos
soil by rain, you should notice what takes place eve
in this country after every series of heavy showers
Each little runnel and brook becomes muddy an
discoloured from the quantity of soil, that is, decaye
rock, which is washed into it by the rain from th
neighbouring slopes. The mud which darkens th
made of the finer particles of the de
the coarser parts are moving along at
water. When you watch these s

their work, and when you remember that what they are doing now they have been doing for ages past, you will understand how greatly the surface of a country may come to be changed by the action of what at first seems so insignificant a thing as Rain.

VI. Brooks and Rivers. Their Origin.

154. We must now go back to an earlier Lesson (Art. 107), where the way in which rain is disposed of was referred to. You remember that one part of the rain sinks under the ground, and you have traced its progress there until it comes to the surface again. You have now to trace, in a similar way, the other portion of the rainfall which flows along the surface in brooks and rivers.

155. You cannot readily meet with a better illustration of this subject than that which is furnished by a gently sloping road during a heavy shower of rain. Let us suppose that you know such a road, and that just as the rain is beginning you take up your station at some part where the road has a well-marked descent. At first you notice that each of the large heavy drops of rain makes in the dust, or sand, one of the little dints or rain-prints already described (Art. 146). As the shower gets heavier these rain-prints are effaced, and the road soon streams with water. Now mark in what manner the water moves.

156. Looking at the road more narrowly, you remark that it is full of little roughnesses—at one place a long rut, at another a projecting stone, with many more inequalities which your eye could not easily detect when the road was dry, but which the water at once discloses. Every little dimple and projection

affects the flow of the water. You see how
raindrops gather together into slender streamlets
running water which course along the hollows, a
how the jutting stones and pieces of earth seem
turn these streamlets now to one side and now
another.

157. Towards the top of the slope only fee
runnels of water are to be seen. But further do
they become fewer in number, and at the same ti
larger in size. They unite as they descend; and t
larger and swifter streamlets at the foot of the desce
are thus made up of a great many smaller ones fr
the higher parts of the slope.

158. Now this sloping roadway, with its branchi
rills of rain, coursing down the slope, and uniting i
larger streams as they advance, shows very well t
way in which the rain runs off the sloping surface o
country or a continent, and we shall return to t
illustration again.

159. Why does the water run down the sloping roa
why do rivers flow? and why should they always mo
constantly in the same direction? They do so for t
same reason that a stone falls to the ground when
drops out of your hand; because they are under t
sway of that attraction towards the centre of the ear
to which, as you know, the name of **Gravity** (Physi
Primer, Art. 4) is given. Every drop of rain falls
the earth because it is drawn downwards by the for
of this attraction. When it reaches the ground it
still, as much as ever, under the same influence; and
flows downwards in the readiest channel it can fin
fall from the clouds to the earth is
; its descent from the mountains to

the rain found them out. Water is thus a most ac rate measurer of the levels of a country. It will flow up a slope, but always seeks the lowest level can find.

162. You can see, then, that though the rain sho fall equally over the whole surface of a country, it c not flow equally over that surface, because the grou is uneven, and the rain runs off into the hollows. is this unevenness which makes the rain collect i brooks, and these into rivers.

163. The brooks and rivers of a country are thus t natural drains, by which the surplus rainfall, not quired by the soil or by springs, is led back again in the sea. When we consider the great amount of ra and the enormous number of brooks in the high parts of the country, it seems, at first, hardly possib for all these streams to reach the sea without ove flowing the lower grounds. But this does not ta place; for when two streams unite into one, they not require a channel twice as broad as either of th single water-courses. On the contrary, such an uni often gives rise to a stream which is not so broad either of the two from which it flows. But it becom swifter and deeper. In this way thousands of strea lets, as they come together in their descent, are ma to take up less and less room, until the surplus wate of a whole vast region are borne into the sea by on single river-channel.

164. Let us return to the illustration of the roadwa in rain. Starting from the foot of the slope, you foun the streamlets of rain getting smaller and sm en you came to the top there were non ever, you were to descend the road

side of the ridge, you would probably meet with other streamlets coursing down-hill in the opposite direction. At the summit the rain seems to divide, part flowing off to one side, and part to the other.

165. In the same way, were you to ascend some river from the sea, you would watch it becoming narrower as you traced it inland, and branching more and more into tributary streams, and these again subdividing into almost endless little brooks. But take any of the branches which unite to form the main stream, and trace it upward. You come, in the end, to the first beginnings of a little brook, and going a little further you reach the summit, down the other side of which all the streams are flowing to the opposite quarter. The line which separates two sets of streams in this way is called the **Water-shed.** In England, for example, one series of rivers flows into the Atlantic, another into the North Sea. If you trace upon a map a line separating all the upper streams of the one side from those of the other, that line will mark the water-shed of the country.

166. But there is one important point where the illustration of the road in rain quite fails. It is only when rain is falling, or immediately after a heavy shower, that the rills are seen upon the road. When the rain ceases the water begins to dry up, till in a short time the road becomes once more firm and dusty. But the brooks and rivers do not cease to flow when the rain ceases to fall. In the heat of summer, when perhaps there has been no rain for many days together, the rivers still roll on, smaller usually than they were in winter, but still with ample flow. What keeps them full? If you remember what you have

already been told about underground-water, you w answer that **rivers are fed by springs as we as by rain.**

167. Though the weather may be rainless, the sprin continue to give out their supplies of water, and the keep the rivers going. But if great drought come many of the springs, particularly the shallow one cease to flow, and the rivers fed by them shrink up get dry altogether. This is the case with the rivers this country, which are all, comparatively speakin very small. The great rivers of the globe, such as th Mississippi, drain such vast territories, that any me local rain or drought makes no sensible difference i their mass of water.

168. In some parts of the world, however, the rive are larger in summer and autumn than they are i winter and spring. The Rhine, for instance, begin to rise as the heat of summer increases, and to fall a the cold of winter comes on. This happens becaus the river has its source among snowy mountains Snow melts rapidly in summer, and the water whic streams from it finds its way into the brooks and rivers which are thereby greatly swollen. In winter, on the other hand, the snow remains unmelted; the moisture which falls from the air upon the mountains is chiefly snow; and the cold is such as to freeze the brooks. Hence the supplies of water at the sources of these rivers are, in winter, greatly diminished, and the rivers themselves become proportionately smaller.

169. **Summary.**—To sum up what has been stated is and the preceding Lessons regarding of water:—From the highest parts

[illegible] of the river [illegible] from [illegible] more or less [illegible] Every [illegible] but large [illegible] It has been [illegible] in one year [illegible] to make three hundred and thirty-two thousand millions of oys shells. This chemically-dissolved material is i visible to the eye, and in no way affects the colour the water. At all times of the year, as long as t water flows, this invisible transport of some of t materials of rocks must be going on.

172. But let us now again watch the same river flood. The water is no longer clear, but dull and dir You ascertained that this discoloration arises frc mud and sand suspended in the water. You may sta for hours and watch the swollen, turbid torrent rolli down its channel. During that time many tons gravel, sand, and mud must be swept past yo You see that over and above the mineral matter chemical solution, the river is hurrying seaward wi vast quantities of other and visible materials. An thus it is clear that at least one great part of the wo of rivers must be to transport the mouldered parts the land which are carried into them by springs c by rain.

173. But the rivers, too, help in the general destruc tion of the surface of the land. Of this you may readil be assured, by looking at the sides or bed of a strean when the water is low. Where the stream flows ove hard rock, you find the rock all smoothed and groun away; and the stones lying in the water-course ar all more or less rounded and smoothed. When thes stones were originally broken by frosts or otherwise from crags and cliffs, they were sharp-edged, as yo can prove by looking at the heaps of blocks lying a the foot of any precipice, or steep bank of rock Bu

they fell, or were washed into the
to get rolled and rubbed, until their

[illegible]

[illegible]

until they actually excavate deep round cavities, called **pot-holes**, in the solid rock. When the water is low, as during the droughts of summer, some of these cavities are laid bare, and you may then observe how well they have been polished. Their general appearance is shown in Fig. 10.

175. Now, it is clear that two results must follow from this ceaseless wear and tear of rocks and stones in the channel of a stream. In the first place, a great deal of mud and sand must be produced; and, in the second place, the bed of the river must be ground down so as to become deeper and wider. The sand and mud are added to the other similar materials washed into the streams by rain from the mouldering surface of the land. By the deepening and widening of the water-courses, such picturesque features as gorges and ravines are excavated out of the solid rock.

176. You have now seen why the rivers are muddy. Let us inquire what becomes of all the mud, sand, gravel, and blocks of stone which they are continually transporting.

177. Look, again, at the channel of a river in summer. You see it covered with sheets of gravel in one place, beds of sand in another, while here and there a piece of hard rock sticks up through these different kinds of river-stuff. Note some portion of the loose materials, and you find it to be continually shifting. A patch of gravel or sand may remain for a time, but the little stones and grains of which it is made up are always changing as the water covers and moves them. In fact, the loose materials over which [illegible] flows are somewhat like the river itself. Y

[illegible] and the [illegible] and [illegible] has [illegible] been [illegible] hanging [illegible] less [illegible] the [illegible] inward. [illegible]

[illegible] The [illegible] like [illegible] has [illegible] and [illegible] so [illegible] The same [illegible] the [illegible] while is also busy deepening its channel, cannot overflow it even at the highest floods. In course of time the river, as it winds from side to side, cuts away slices of the plain and forms a newer one at a lower level. And thus a series of terraces is gradually made, rising step by step above the river.

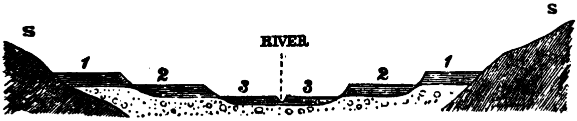


FIG. 11.—Section of the successive terraces (1, 2, 3) of sand, earth, and gravel formed by a River along a valley (s—s).

179. Still the laying down of its sand and mud by a river to form one or more such river-terraces is, after all, only a temporary disposal of these materials. They are still liable to be carried away, and in truth they are carried off continually as the river eats away its banks.

180. When the current of a river is checked as it enters the sea or a lake, the feebler flow of the water allows the sand and mud to sink to the bottom. By degrees some portions of the bottom come in this way to be filled up to the surface of the river, and wide flat marshy spaces are formed on either side of the main stream. During floods these spaces are overflowed with muddy water, in the same way as in the case of the valley plains just described, and a coating of mud or sand is laid down on them until they slowly rise above the ordinary level of the river, which winds about among them in endless branching treams. Vegetation springs up on these flat s nds; animals, too, find food and shelter the

[illegible] the work of the [illegible]

[illegible] called Deltas, [illegible] the ancients, [illegible] Greek letter [illegible] which is taken

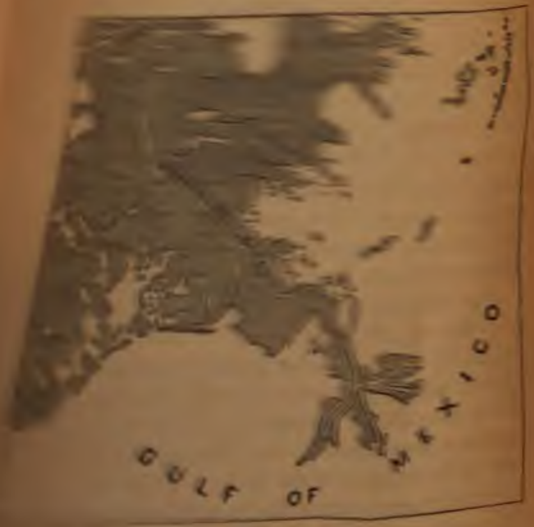


Fig. 11.—Delta of the Mississippi.

[illegible] at the mouths of rivers; the flat [illegible] the inland, and broader [illegible] them are of enormous [illegible], for example.

[illegible] of materials worn [illegible] brought down by the river. And yet vast though some of these deltas they do not show all the materials which have l so worn away. A great deal is carried far out deposited on the sea-bottom; for the sea is the g basin into which the spoils of the land are contint borne.

VIII. Snow-fields and Glaciers.

183. Having now followed the course taken by water which falls on the land as rain, we come to taken by snow (Art. 92).

184. On the tops of some of the highest mount in Britain snow lies for great part of the year. some of them, indeed, there are shady clefts whe you may meet with deep snow-wreaths even in heat of summer. It is only in such cool and shelt spots, however, that the snow remains unmelted.

185. But in other parts of Europe, where the m tains are more lofty, the peaks and higher shoulde the hills gleam white all the year with unmelted s Hardly anything in the world will impress you much as the silence and grandeur of these high sn regions. Seen from the valleys, the mountains loo vast and distant, so white and pure, yet catching so wonderfully all the colours which glow in the at morn or even, that they seem to you at first ra parts of the heaven above than of the solid eart which we live. But it is when you climb up f into their midst that their wonderful stateliness co before you. Peaks and pinnacles of the ng whiteness glisten against the dark blue of d here and there with line with knobs of the dark rc

[illegible]

[illegible] that there is

a line or limit below which the ground gets freed its snow, and above which the snow remains. T limit is called the **snow-line**, or the **limit perpetual snow.** Its height varies in differe parts of the world. It is highest in the warn regions on either side of the equator, where it reach to 15,000 feet above the sea. In the cold po tracts, on the other hand, it approaches the sea-lev In other words, while in the polar tracts the clim is so cold that perpetual snow is found even clc to the sea-level, the equatorial regions are so wa that you must climb many thousand feet before y can reach the cold layers of the air where snow c remain all the year.

188. You have no doubt watched a snow-ston You have seen how at first a few flakes begin to shc themselves drifting through the air; how they g more in number and larger in size, until the groun begins to grow white; and how, as hours go on, tl whole country becomes buried under a white pa perhaps six inches or more in thickness. You s one striking difference between rain and snow. rain had been falling for the same length of tim the roads and fields would still have been visible, f each drop of rain, instead of remaining where it fe would either have sunk into the soil, or have flowe off into the nearest brook. But each snowflake, c the contrary, lies where it falls, unless it happens t be caught up and driven on by the wind to som other spot where it can finally rest. Rain disappea from the ground as soon as it can; snow stays sti as long as it can.

You will see at once that this m

[illegible] of behaviour must give rise to some equally strong differences in the further progress of these two kinds of moisture. You have followed the progress of the rain; now let us try to find out what becomes of the snow.

190. *In such a country as ours, where there is no perpetual snow, you can without much difficulty answer this question. Each fall of snow in winter-time remains on the ground as long as the air is not warm enough to melt it.* Evaporation, indeed, goes on from *the surface of snow and ice*, as well as from water; so *that a layer of snow* would in the end disappear, by *being absorbed into the air as vapour*, even though none *of it had previously* been melted into running water. But *it is by what* we call a **thaw** that our snow is usually *dissipated*; that is, a rise in the temperature, and a consequent melting of the snow. When the snow melts, it sinks into the soil and flows off into [illegible] in the same way as rain. Its after course [illegible] to be followed, for it is the same as that [illegible]. You will only bear in mind that if a [illegible] snow should be quickly thawed, then [illegible] water will be let loose over the [illegible] brooks and rivers will rise rapidly [illegible] tion may thus be caused by [illegible] and the overflowing of their

[illegible] perpetual snow the heat of [illegible] snow which falls there in [illegible] escape, then, can the [illegible] have some means [illegible] clear enough; for [illegible] there from ear to year and from century to century, then ountains would grow into vast masses of snow, re g far into the sky, and spreading out on all si as to bury by degrees the low lands around. othing of this kind takes place. These sole owy heights wear the same unchanged look f neration to generation. There is no burying eir well-known features under a constantly incr g depth of snow.

192. You will remember that the surplus rain ws off by means of rivers. Now the surp ow-fall above the snow-line has a similar kind ainage. It flows off by means of what are cal **laciers.**

193. When a considerable depth of snow has ac lated, the pressure upon the lower layers fr at lies above them squeezes them into a fi ss. The surface of the ground is usually slop some direction, seldom quite flat. And amo the high mountains the slopes are often, as y know, very steep. When snow gathers deeply sloping ground, there comes a time when the for of gravity overcomes the tendency of the presse snow to remain where it is, and then the sno begins to slide slowly down the slope. From on slope it passes on downwards to the next, joine continually by other sliding masses from neighbou ing slopes until they all unite into one long tongu which creeps slowly down some valley to a poin where it melts. This tongue from the snow-fields i the glacier. It really drains these snow-fields of snow as much as a river drains a s of water.

194. But the glacier which comes out of the snow-fields is itself made not of snow, but of ice. The snow, as it slides downward, is pressed together into ice. You have learned that each snowflake is made of little crystals of ice. A mass of snow is thus only a mass of minute crystals of ice with air between. Hence when the snow gets pressed together, the air is squeezed out, and the separated crystals of ice freeze together into a solid mass. You know that you can make a snowball very hard by squeezing it firmly between the hands. The more tightly you press it the harder it gets. You are doing to it just what happens when a glacier is formed out of the eternal snows. You are pressing out the air, and allowing the little particles of ice to freeze to each other and form a compact piece of ice. But you cannot squeeze nearly all the air out, consequently the ball, even after all your efforts, is still white from the imprisoned air. Among the snowfields, however, the pressure is immensely greater than yours; the air [illegible] more and more pressed out, and at last the snow becomes clear transparent ice.

195. A glacier, then, is a river, not of water, but of [illegible] coming down from the snow-fields. It descends sometimes a long way below the snow-line, creeping [illegible] very slowly along the valley which it covers [illegible] side. Its surface all the time is melting [illegible] in summer, and streams of clear [illegible] along the ice, though, when night [illegible] freeze. At last it reaches some [illegible] which it cannot go, for [illegible] is melting the ice as fast [illegible] ends, and from its

melting extremity streams of muddy water unite into a foaming river, which bears down the drainage of the snow-fields above.

196. In the accompanying woodcut (fig. 13) some of the chief characters of a glacier are shown. In the distance rise the snowy heights, among which the snow-

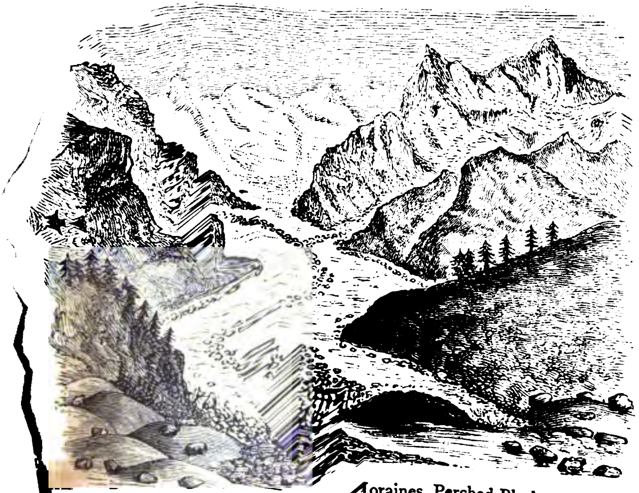


FIG. 13.—View of a Glacier, with its Moraines, Perched Blocks of rock, ice-worn Bosses of rock and escaping River.

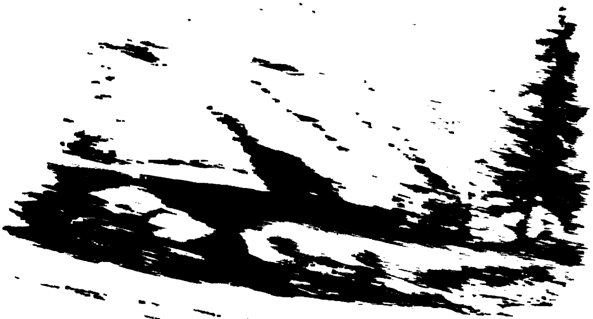
fields lie. From either side the snow is drained off into the main valley, where it forms the glacier, which nds with all the windings of the valley till it ends ptly, as you see, and a river rushes out from the ng end of the ice.

7. A river wears down the sides and bot hannel, and thus digs out a bed for itself

[illegible] softest soil [illegible] quantity of [illegible] in the sea [illegible] same kind of [illegible]

[illegible] sink to the [illegible] current. [illegible] enters a river it remains [illegible] in the water, and is thus carried along. [illegible] of a [illegible] is a solid substance. [illegible] which [illegible] on its surface remain there, [illegible] borne onward with the whole mass of the moving glacier. [illegible] form long lines of rubbish [illegible] glacier as [illegible] in Fig. 13, and are called **moraines**. [illegible] often gets broken up into deep [illegible] cracks or **crevasses**, which sometimes [illegible] a great deal of the earth and stones [illegible] loose [illegible] otherwise from the sides of the valley. In [illegible] materials fall to the bottom of the ice, [illegible] floor of the valley down which the [illegible] at the same time [illegible] between the edge of the glacier and the side [illegible]

[illegible] the rock over which it is moving [illegible] this rock. They form [illegible] whereby the glacier [illegible] down the bottom and sides of [illegible] you creep in below the ice, or catch a [illegible] ured a little, [illegible] bbed away [illegible] y the sharp [illegible] from which the ice has [illegible] surface of the rock all [illegible] long scratches mad [illegible] and sand. Some [illegible]



[illegible] happens

[illegible] of water

[illegible] the water

Sunk deep in the sea, therefore, the icebergs float to and fro until they melt, sometimes many hundreds of miles away from the glaciers which supplied them.

203. You will come to learn afterwards that, once upon a time, there were glaciers in Britain. You will be able with your own eyes to see rocks which have been ground down and scratched by the ice, and big blocks of rock and piles of loose stones which the ice carried upon its surface. In Wales, and Cumberland, in many parts of Scotland, and also in Ireland, these and many other traces of the ice are to be found. So that, in learning about glaciers, you are not merely learning what takes place in other and distant lands, you are gaining knowledge which you will b by and by to make good use of, even in y country.

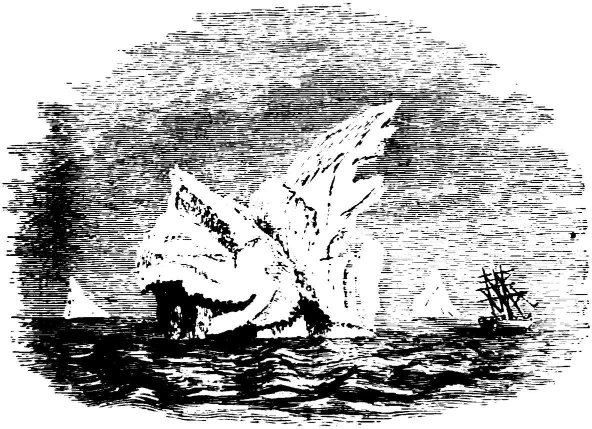


Fig. 16.—Iceberg at Sea.

THE SEA.

I. Grouping of Sea and Land.

204. Since we live on land, and are familiar with the various shapes which the surface of the land assumes,—plains, valleys, hills, mountains, and so on,—we are apt to think that the land is the main part of the globe. Many of us who live in the inland parts of the country have never been off the land, nor seen any larger sheet of water than a river or a lake, or perhaps a large reservoir. And yet, if you were to travel onward in any direction in Great Britain, you would at last come to the edge of the land, and find a vast expanse of water before you. If you took your place in a ship, you could sail on that water completely round this country, and you would prove in so doing that Britain is an **island.**

205. Suppose that instead of sailing round Britain, which you could easily do in a few weeks, you were to steer straight westward. You would have to travel over the water for more than two thousand miles before you reached any land again. Or, if you directed your ship in a more southerly course, you might sail on without seeing any land for months together, til you came in sight of the ice-cliffs that border land round the South Pole. You would learn in way what an enormous extent of the surface of earth is occupied by water.

206. It has been ascertained that in reality the ater cover [illegible] times more of the earth's urface tha [illegible] We could not tell that merely by [illegible] from any part of this country, [illegible] ountry. It is because

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film under a microscope you see it to consist of delicate crystals of common or sea salt. It would not matter from what ocean you took the drop of water, it would still show the crystals of salt on being evaporated.

213. There are some other things besides common salt in sea-water. But the salt is the most abundant, and we need not trouble about the rest at present. Now, where did all this mineral matter in the sea come from? **The salt of the sea is all derived from the waste of the rocks.**

214. It has already been pointed out (Arts. 125, 132) how, both under ground and on the surface of the land, water is always dissolving out of the rocks various mineral substances, of which salt is one. Hence the water of springs and rivers contains salt, nd this is borne away into the sea. So that all ver the world there must be a vast quantity of salt urried into the ocean every year.

215. The sea gives off again by evaporation as much ater as it receives from rain and from the rivers of e land. But the salt carried into it remains behind. you take some salt water and evaporate it, the pure ter disappears, and the salt is left. So it is with sea. Streams are every day carrying fresh supplies salt into the sea. Every day, too, millions of tons water are passing from the ocean into vapour in atmosphere. The waters of the sea must con-uently be getting salter by degrees. The process, ever, is an extremely slow one.

6. Although sea-water has probably been gradually ing in saltness ever since rivers first flowed great sea, it is even now by no means as ght be. In the Atlantic Ocean, for exam

hundreds of miles. This **surface-drift** of the sea-water corresponds generally with the direction in which the prevalent winds blow.

220. But it is not merely the surface-water which moves. You have learnt a little about icebergs (Art. 202); and one fact about them which you must remember is that, large as they may seem, there is about seven times more of their mass below water than above it. Now, it sometimes happens that an iceberg is seen sailing on, even right in the face of a strong wind. This shows that it is moving, not with the wind, but with a strong under-current in the sea. In short, the sea is found to be traversed by many **currents,** some flowing from cold to warm regions, and others from warm to cold.

221. Here, then, are four facts about the sea:—1st, it has a restless surface, disturbed by ripples and waves; 2ndly, it is constantly heaving with the ebb and flow of the tides; 3rdly, its surface-waters drift with the wind; and 4thly, it possesses currents like the atmosphere.

222. For the present it will be enough if we learn something regarding the first of these facts—**the waves of the sea.**

223. Here again you may profitably illustrate by familiar objects what goes on upon so vast a scale in nature. Take a basin, or a long trough of water, and blow upon the water at one edge. You throw its surface into ripples, which, as you will observe, start from the place where your breath first hits the water and roll onward until they break in little wavelets upon the opposite margin of the basin.

224. What you do in a small way is the same acti

and the shores are strewn with the wreck of ships. So that, besides all the waste which the surface of the land undergoes from rain, and frost, and streams, there is another form of destruction going on along the coast-line.

228. On rocky shores the different stages in the eating away of the land by the sea can sometimes be strikingly seen. Above the beach perhaps rises a cliff, sorely battered about its base by the ceaseless grinding of the waves. Here and there a cavern has been drilled in the solid wall, or a tunnel has been driven through some projecting headland. Not far off we may note a tall buttress of rock, once a part of th main cliff, but now separated from it by the falling i removal of the connecting archway. [illegible]en
off from the cliff, isolated, half-
show where still older detached

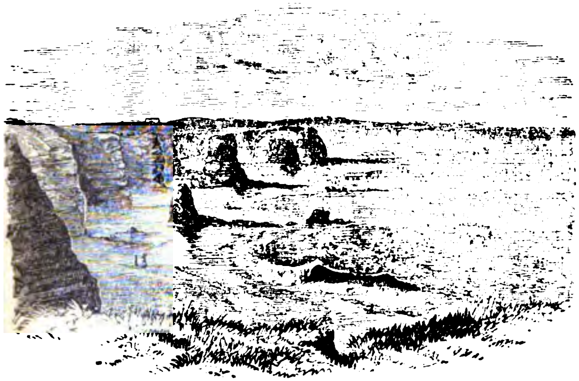

Fig. 17.—Coast-line worn by the Sea.

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nd and stones on the beach
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growing finer, is swept away
down at the bottom.

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orward, and batter the rocks with th
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these stones gather together, and when
gh they are kept whirling and grindin
the cliff till, in the end, a cave is actu
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el. The stones of course are ground to s
e process, but their place is supplied by oth
t up by the waves. If you enter one of th
caves when the water is low, you will see h
oothed and polished its sides and roof are, a
w well rounded and worn are the stones ly
ts floor.

V. The Bottom of the Sea.

So far as we know, the bottom of the sea
ch like the surface of the land. I
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e down to the bottom where

very deep, but we can let down a long line with a weight tied to the end of it, and find out both how deep the water is, and what is the nature of the bottom, whether rock or gravel, sand, mud, or shells. This measuring of the depths of the water is called **Sounding**, and the weight at the end of the line goes by the name of the **Sounding-lead.**

234. Soundings have been made over many parts of the sea, and something is now known about its bottom, though much still remains to be discovered. The Atlantic Ocean is the best known. In sounding it, before laying down the telegraphic cable which stretches across under the sea from this country to America, a depth of 14.500 feet, or two miles and three-quarters, was reached. But between the Azores and the Bermudas a sounding has been obtained of seven miles and a half. If you could lift up the Himalaya mountains, which are the highest on the globe, reaching a height of 29.000 feet above the sea, and set them down in the deepest part of the Atlantic, they would not only sink out of sight, but their tops would actually be about two miles below the surface.

235. A great part of the wide sea must be one or two miles deep. But it is not all so deep as that, for even in mid-ocean some parts of its bottom rise up to the surface and form islands. As a rule it deepens in the tracts furthest from land, and shallows towards the land. se parts of the sea which run in among omontories are, for the most part, low. To the west of the island co retches the wide Atlantic Ocean of much smaller North Sea; the form deep as we sail west-

wards across it, the latter never deepening much even over its middle parts, which are nowhere so much as 400 feet below the surface. You may get some notion of the shallowness of the sea between this country and France, when you are told that if you could lift St. Paul's cathedral from London, and set it down in the middle of the Strait of Dover, more than a half of the building would be out of the water.

236. You may readily enough understand how it is that soundings are made, though you can see how difficult it must be to work a sounding-line several miles long. Yet men are able not only to measure the depth of the water, but by means of the instrument called a **dredge,** to bring up bucketfuls of whatever may be lying on the sea-floor, from even the deepest parts of the ocean. In this way during the last few years a great deal of additional knowledge has been gathered as to the nature of the sea-floor, and the kind of plants and animals which live there. We now know that even in some of the deepest places which have yet been dredged there is plenty of animal life, such as shells, corals, star-fishes, and still more humble creatures.

237. In earlier parts of this book we have traced some of the changes which from day to day take place upon the surface of the land. Let us now try to watch some of those which go on upon the floor of the sea. We cannot, indeed, examine the sea-botto with anything like the same minuteness as the surfac of the land. Yet a great deal may be learnt regar ing it.

238. If you put together some of the ch we have been dealing in the

bottom of the deep sea. Consequently that om lies beyond the reach of the various kinds destruction which so alter the face of the land. materials which are derived from the waste of land can lie on the sea-floor without further disurbance than they may suffer from the quiet flow of ch ocean currents as touch the bottom.

241. In what way, then, are the gravel, sand, and ud disposed of when they reach the sea?

242. As these materials are all brought from the and, they accumulate on those parts of the sea-floor which border the land, rather than at a distance. We may expect to find banks of sand and gravel in shallow seas and near land, but not in the middle of the ocean.

243. You may form some notion, on a small scale, as to how the materials are arranged on the sea-bottom, by examining the channel of a river in a season of drought. At one place, where the current has been strong, there may be a bank of gravel; at another place, where the currents of the river have met, you will find, perhaps, a ridge of sand which they have heaped up; while in those places where the flow of the stream has been more gentle, the channel may be covered with a layer of fine silt or mud. You remember that a muddy river may b made to deposit its mud if it overflows its banks far as to spr ad over flat land which checks its fl (Art

re powerful a current of water, t
stones it can move alon
t likely to be found over
near the land, where th

the bed of the Atlantic Ocean is covered with fine mud, which on examination is found to consist almost wholly of the remains of very minute animals called **Foraminifera.**

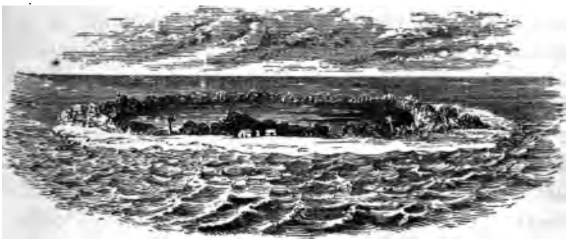

FIG. 18.—Island formed by the Growth of Coral.

248. Over the bottom of the sea, therefore, great beds of sand and mud, mingled with the remains of plants and animals, are always accumulating. If now this bottom could be raised up above the sea-level, even though the sand and mud should get as dry and hard as any rock among the hills, you would be able to say with certainty that they had once been under the sea, because you would find in them the shells and other remains of marine animals.

249. You will afterwards learn when you come to the science of Geology that this raising of the sea-bottom has often taken place in ancient times. You will find most of the rocks of our hills and valleys to have been originally laid down in the sea, where they were formed out of sand and mud dropped on the sea-floor, just as sand and mud are carried out to sea and laid *down there now.* And in these rocks, not merely *near the shore,* but far inland, in quarries or ravines

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pest mine is not more in comparison than the
e varnish on the outside of a school-globe. And
a good deal can be learnt as to what takes place
in the earth. Here and there, in different coun-
, there are places where communication exists
een the interior and the surface; and it is from
places that much of our information on this
ct is derived.

4. You have, no doubt, read of **Volcanoes** or
ing-mountains (fig. 19). These are among
ost important of the channels of communication
the interior.

5. Let us suppose that you were to visit one of
volcanoes just before what is called "an eruption."
u approach it, you see a conical mountain, seem-
with its top cut off. From this truncated sum-
white cloud rises. But it is not quite such a
as you would see on a hill-top in this country.
as you watch it you notice that it rises out of
top of the mountain, even though there are no
ds to be seen anywhere else. Ascending from
vegetation of the lower grounds, you find the
s to consist partly of loose stones and ashes,
of rough black sheets of rock, like the slags of
n furnace. As you get nearer the top the ground
hot, and puffs of steam, together with stifling
s, come out of it here and there. At last you
the summit, and there what seemed a level top
to be in reality a great basin, with stee
escending into the depths of the mountai
g your face as well as possible from the h
almost choke you, you creep t
n, and look down into it. Fa

by the violence of the explosions with which the gases and steam escape.

257. The hot air and steam, and the melted mass at the bottom of the crater, show that there must be some source of intense heat underneath. And as the heat has been coming out for hundreds, or even thousands of years, it must exist there in great abundance.

258. But it is when the volcano appears in active eruption that the power of this underground heat shows itself most markedly. For a day or two beforehand, the ground around the mountain trembles. At length, in a series of violent explosions, the heart of the volcano is torn open, and perhaps its upper part is blown into the air. Huge clouds of steam roll away up into the air, mingled with fine dust and red-hot stones. The heavier stones fall back again into the crater or on the outer slopes of the mountain, but the finer ashes come out in such quantity, as sometimes to darken the sky for many miles round, and to settle down over the surrounding country as a thick covering. Streams of white-hot molten lava run down the outside of the mountain, and descend even to the gardens and houses at the base, burning up or overflowing whatever lies in their path. This state of matters continues for days or weeks, until the volcano exhausts itself, and then a time of comparative quiet comes when only steam, hot vapours, and gases are given off.

259. About 1800 years ago, there was a mountain near Naples shaped like a volcano, and with a large crater covered with brushwood (fig. 20). No one had ever seen any steam, or ashes, or lava come from it, and the people did not imagine it to be a volcano, li

pletely did they disappear, that, although important places at the time, their very sites were forgotten, and only by accident, after the lapse of some fifteen hundred years, were they discovered. Excavations have since that time been carried on, the hardened volcanic accumulations have been removed from the old city, and you can now walk through the streets of Pompeii again, with their roofless dwelling-houses and shops, theatres and temples, and mark on the causeway the deep ruts worn by the carriage wheels of the Pompeians eighteen centuries ago. Beyond the walls of the now silent city rises Mount Vesuvius, with its smoking crater, covering one-half of the old mountain which was blown up when Pompeii disappeared. (See fig. 19.)

260. Volcanoes, then, mark the position of some of the holes or orifices, whereby heated materials from the inside of the earth are thrown up to the surface. They occur in all quarters of the globe. In Europe, besides Mount Vesuvius, which has been more or less active since it was formed, Etna, Stromboli, and other smaller volcanoes, occur in the basin of the Mediterranean, while far to the north-west some active volcanoes rise amid the snows and glaciers of Iceland. In America a chain of huge volcanoes stretches down the range of mountains which rises from the western margin of the continent. In Asia they are thickly grouped together in Java and some of the surrounding islands; and stretch thence through Japan and the Aleutian Isles, to the extremity of North America. If you trace this distribution upon the map, you will see that *the Pacific* Ocean is girded all round with volcanoes.

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CONCLUSION.

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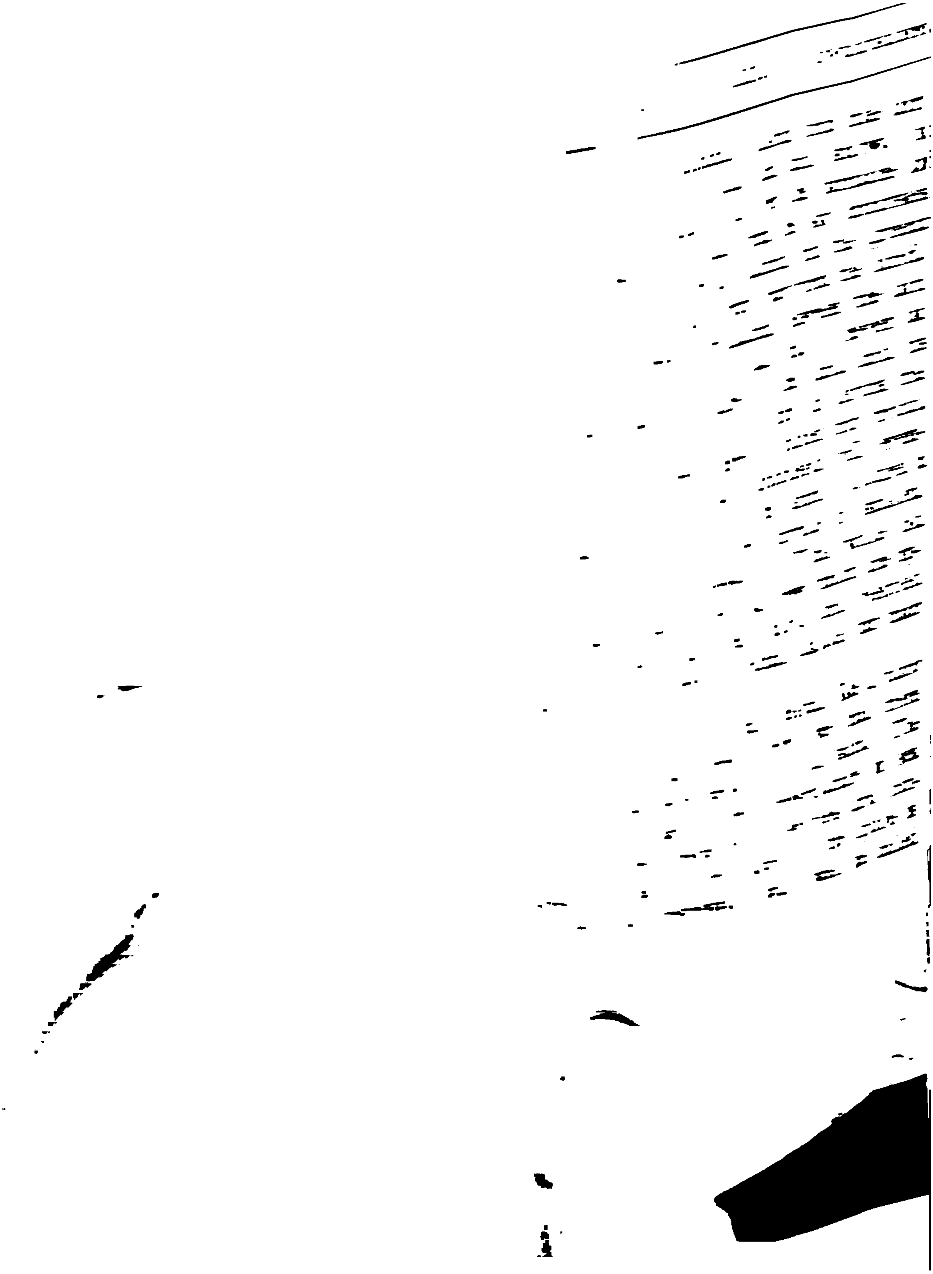

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